

Geographic Distribution of 'Champion Mine' Strain of White Pine Blister Rust (*Cronartium ribicola*) in the Pacific Northwest

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Introduction:

The introduced pathogen, white pine blister rust (*Cronartium ribicola*) is a key factor in widespread mortality of western white pine (*Pinus monticola*) and other five-needle pines in the western United States. Since the mid-1950's, the USDA Forest Service, along with cooperators such as the USDI Bureau of Land Management, have been actively engaged in a program to develop genetic resistance to blister rust for *P. monticola* and *P. lambertiana* in Oregon and Washington (see www.fs.fed.us/r6/dorena). Seed orchards have been established and for many of the breeding zones resistant seed is available (or will be in the near future). Resistant seed is used in reforestation and restoration efforts to help ensure these species remain viable components of the Pacific Northwest ecosystems.

The most dramatic resistance mechanisms in both of western white pine and sugar pine is a hypersensitive reaction (HR) in the needles controlled by a single major gene (different genes in the two species, Cr1 in sugar pine, Cr2 in western white pine). A recently completed project has determined the general geographic distribution of genotypes with Cr2 in western white pine (unpublished data, and Figure 1). These individuals are usually canker-free, but there are a few small geographic areas where there is known to be a strain of rust (and the putative gene 'vcr2') virulent to Cr2 (notably the Champion Mine area on the Umpqua National Forest for western white pine). HR individuals develop normal stem symptoms after infection with the virulent strain of rust.

Efficient utilization of resistant seedlings by land managers will depend upon knowledge of several factors, including rust hazard of the site and the existence or potential presence of a virulent strain of rust that might render some resistance mechanisms ineffective. This project was undertaken to determine whether a strain of blister rust virulent to Cr2 in western white pine existed beyond the 'Champion Mine' area, and if so, how widespread it might be. This knowledge will aid in developing deployment strategies for resistant stock, and for efficiently planning breeding efforts, as well as providing basic information on spread of new strains of blister rust. Collections from this project were also used to inoculate resistant (Cr1) sugar pine and assess their resistance (unpublished data).

Figure 7. Mary's Peak collection site



a) Infected *Ribes*



b) Healthy tree



c) Dead and stunted trees

Figure 3. *P. monticola* planting at Grass Creek collection site



Materials and Methods:

•In the summers of 1999 and 2000, *Ribes* leaves infected with *Cronartium ribicola* were collected in Oregon, Washington, and California. The major focus of testing in 1999 was the 'Champion Mine' area, while the general focus of the 2000 testing was region-wide (Figure 2). Some collection sites were in or adjacent to *P. monticola* plantings (Figure 3).

•Seedlings were inoculated while still in the cotyledon or early primary needle stage (a few weeks after germination).

•The assayed seedlings were from known major gene resistance (HR) parents, from recently identified homozygous (RR) parents. Approximately 10 seedlings (5-14) were used to evaluate spore cast from each *Ribes* source. The number of needle spots evaluated per inoculum source varied from 1 to 127 in 1999, and from 6 to >400 in 2000).

•Seedlings were inoculated in a 'dew' chamber (Figure 4); each source of *Ribes* was used in separate inoculations from August to October.

•Seedlings were scored when spots appeared on the needles, usually 6-8 weeks after inoculation. One spot = one infection. Spots were classified (phenotyped) and counted. Phenotypes: (1) virulent (vcr2) = yellow spot; avirulent (AVCr2) = necrotic margin around spot (or necrotic fleck instead of spot) (Figure 5). Subsequent confirmation was made by observing stem symptoms of infection.

•The number of spots rated 'virulent' or 'avirulent' was used to obtain an approximate frequency of the putative vcr2 gene in each inoculum.

Resistant (a) and susceptible (b) Cr2 genotype

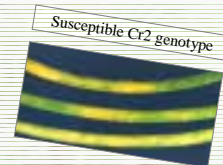
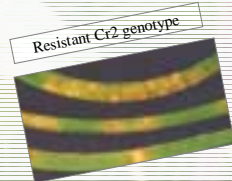


Figure 5. *Pinus monticola* needles from resistant (Cr2) seedlings following inoculation with Champion Mine strain of blister rust

Figure 1. Geographic distribution of a major gene (Cr2) for hypersensitive reaction to *Cronartium ribicola* in *Pinus monticola* needles

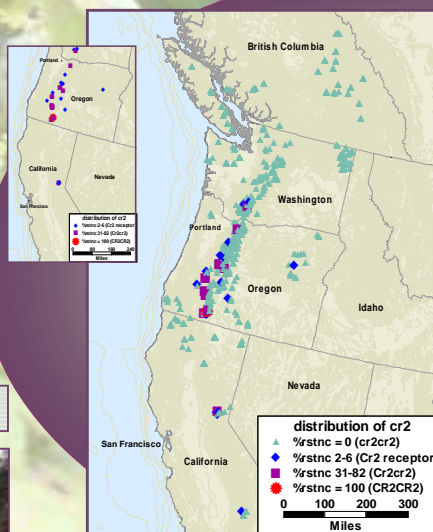


Figure 2. Geographic distribution and frequency of vcr2 strain of *Cronartium ribicola* in the Pacific Northwest (based upon 1999 and 2000 sample years).

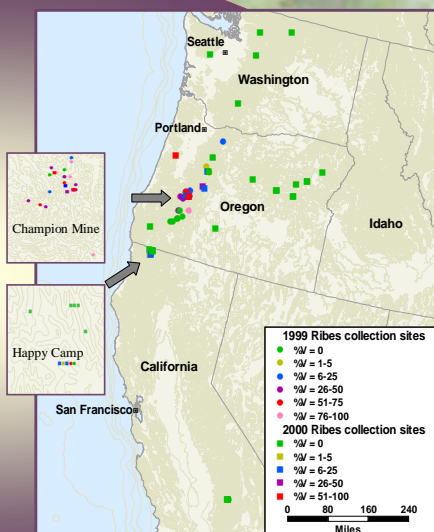
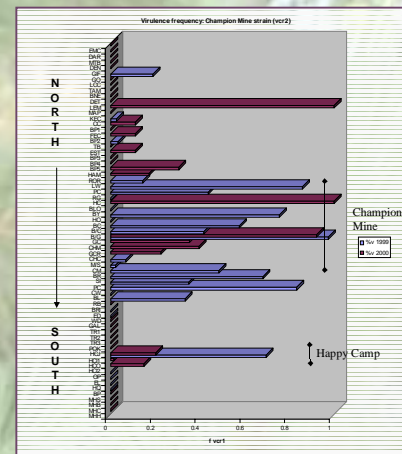


Figure 6. Frequency of putative vcr2 virulence gene for *Cronartium ribicola* at 66 locations in the Pacific Northwest



Results and Discussion

•Several sites had collections tested for vcr2 in both years (notably some sites around Champion Mine) and results were generally similar in both years.

•Twenty of the 30 collection areas from which *Ribes* were sampled in 1999 indicated an incidence of the virulent race, with the frequency of vcr2 varying from 2 to 100% (Figure 2 and Figure 6); 12 of 36 geographic areas tested in 2000 showed a frequency of vcr2 >0% (varying from 1 to 100%).

•In general, vcr2 seems to be present west of the Cascades in Oregon (frequency ranges from low to high), and also near Happy Camp, California.

•Only a few locations were sampled in California so the southward distribution of vcr2 is uncertain.

•vcr2 was present in most of the collections from Cottage Grove Ranger District in the general vicinity Champion Mine (first known occurrence of race of blister rust virulent to Cr2).

•The collection of *Ribes* from the Mary's Peak area (in the Coast Range near Corvallis, Oregon) was from infected leaves inter-dispersed among a planting of western white pine; all of the WWP at this site (except for a few trees) were dead or heavily infected and stunted (Figure 7). No details are currently available concerning the planting stock used for this planting, but resistant seed with HR was probably available for that breeding zone. If so, the high incidence of vcr2 may be from a combination of factors including high hazard site and selection (Cr2 western white pines being prevalent in the area).

•Tested areas showing no incidence of vcr2 may indicate an absence of vcr2 in the area or a frequency lower than the resolving power here. In any case, there appear to be several large parts of Oregon and Washington with no measurable incidence of vcr2.

•Results from this project indicate that the 'Champion Mine' strain of blister rust exists beyond the Champion Mine vicinity, and seems to correspond somewhat to the general range of the resistance gene (Cr2).

•The Pacific Northwest *C. ribicola* resistance program for *P. monticola* will continue to emphasize selection and breeding for durable resistance, incorporating an array of resistance mechanisms. Information from this project will help in guiding strategies in the future.



Figure 4. Inoculation in dew chamber

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